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MILITARY HYDROLOGY

Report 3

A REVIEW OF ARMY DOCTRINE ON MILITARY HYDROLOGY

by

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June 1981

Report 3 of a Series

Prepared for Office, Chief of Engineers, U. S. Army
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Military hydrology is a specialized area of study that deals with the characteristics of surface and subsurface water features that may affect the planning and conduct of military operations. A study was conducted to review Army doctrine on military hydrology to determine its relevance to modern Army needs. Documents were reviewed with respect to five thrust areas: (a) organization, (b) meteorology, (c) soil moisture, (d) streamflow, and (e) water

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supply. It was found that many of the documents reviewed, including AR's, FM's, TR's, and TM's, incorporated TOE's, doctrinal concepts, and technologies of the 1950's. Recommendations were made including suggestions on what modern methodologies and doctrinal concepts should be adopted and what changes can be made to facilitate better understanding of the documents.

PREFACE

The work reported herein was conducted from September 1979 to December 1980 under the Department of the Army P ject No. 4A762719AT40, "Mobility and Weapons Effects Technology," Task Area BO, "Combat Engineering," Work Unit 030, "Military Hydrology Technology Transfer," sponsored by the Office, Chief of Engineers, OCE. Messrs. Herman Roeland and Walter Swain were the Technical Monitors for OCE.

The study was conducted by the U. S. Army Engineer Waterways Experiment Station (WES) under the general supervision of Dr. John Harrison, Chief of the Environmental Laboratory (EL), and Mr. B. O. Benn, Chief of the Environmental Systems Division (ESD), EL, and under the direct supervision of Dr. L. E. Link, Jr., Chief of the Environmental Constraints Group (ECG), EL. This report was prepared by Mr. D. L. Stinson, Research Civil Engineer, ECG.

Water supply and streamflow materials were reviewed by personnel of Texas A&M University, College Station, Tex., and of the Geotechnical and Environmental Laboratories at the WES. Personnel of the Atmospheric Sciences Laboratory, White Sands, N. Mex., reviewed documents dealing with meteorology.

Commander and Director of the WES during this study was COL Nelson P. Conover, CE. The Technical Director of the WES was Mr. Fred R. Brown.

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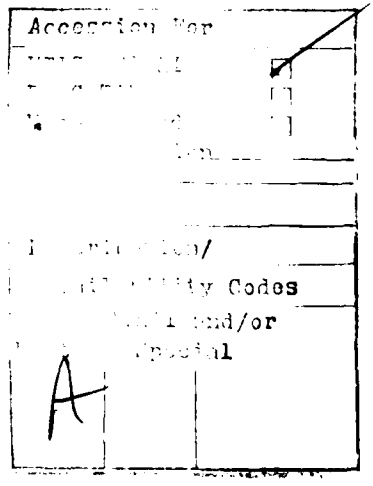

CONTENTS

MILITARY HYDROLOGY

A REVIEW OF ARMY DOCTRINE ON MILITARY HYDROLOGY

PART I: INTRODUCTION

Background

1. Historical accounts make it clear that hydrology has proved a controlling factor in almost every major military campaign. This was demonstrated repeatedly in World War II (WWII), Korea, and Vietnam. Flooded river crossings, washed-out bridges, impassable muddy terrain, insufficient water supply--all are hydrologic problems which affect military operations. While it is generally true that little can be done to prevent or alter such conditions, it is nonetheless necessary to function in spite of them. Conversely, they can be valuable allies if taken advantage of.

2. The responsibility for providing hydrologic support is vested in the Army by JCS memorandum of Policy 46 and is outlined by joint regulations AR 115-10/AFR 105-3 and AR 115-21/AFR 105-10. Meteorological support to the Army for soil trafficability, river stage, and flood forecasts is the responsibility of the Air Force as outlined in AR 115-10/AFR 105-3, AR 115-12, and delegated by JCS memorandum of Policy 46. The terrain team is the Army unit responsible for hydrologic data collection, interpretation, and analysis. The terrain team members have varied training in technical and engineering disciplines located at Theater Army level (TOE 5-336), Corps level (TOE 5-540IJ), and Division level (TOE 5-540IK). The Theater Army team is in general support while those at Corps and Division are direct support teams.

3. Hydrologic support to the Army must be compatible with the way the Army plans to fight in the 1980's and 1990's (i.e., making use of high mobility, countermobility, concentration of firepower, dispersion of assets, and maximum use of communications). Current doctrine supports, to a large extent, the way the Army was configured to operate in the 1950's and 1960's. The basic difference is that today's Army requires much

more hydrologic data over larger areas and needs the data faster and at a lower cost in manpower and other assets. As such, hydrologic support for the modern Army can only be achieved through the use of advanced technology.

4. Many improved techniques have been developed since WWII and the Korean Conflict, among them being the development of sophisticated computer hardware systems and hydrologic models; these are currently being used in the civil sector with considerable success.

5. A second area of rapid and extensive change has been in the acquisition and portrayal of terrain data, making it no longer necessary for a hydrologist to go into an area with little knowledge of soil, vegetation, land use, and other hydrologic parameters. For example, satellite data can now provide useful information on many hydrologic parameters for any point on the globe. Further ground surface elevation data can be determined accurately by airborne laser and radar techniques. The analyses of these data, however, to provide inputs to hydrologic forecast procedures can be time-consuming and difficult to accomplish in a combat environment. The availability of prepared data bases (i.e., for areas of interest) and the use of microprocessor equipment developed in the past decade can potentially alleviate such problems.

6. Finally, in the past 20 years man's understanding of and ability to observe the weather have improved greatly. Proper use of timely weather information may prove the most critical single feature of hydrology in modern combat, in that weather can produce very substantial and abrupt changes in conditions. Weather is important from several perspectives--long-range forecasts for planning operations, shorter range forecasts for decisionmaking during conduct of operations, and the ability to monitor weather over friendly and threat areas for real-time assessments of unit performance on both sides. Because expected flows of information may be interrupted in combat, it is essential that the field element possess capabilities for both localized observing and short-range forecasting. Recent advances in rainfall observation and flood forecasting offer the hydrologist many new methods directly applicable for use in the combat zone.

7. Although in some instances technology is already available to update Army hydrologic procedures, the best procedure will be of little use if it is not incorporated in the appropriate Army literature. To make the needed revisions it is first necessary to identify, in conjunction with state-of-the-art technology, TOE's, and assigned missions, those areas where existing doctrine and procedures are outdated. This will allow immediate updates where better procedures, methods, and equipment exist and will permit focusing research and development resources on areas that require improved capabilities but for which no readily available update exists.

Objective

8. The objective of the work reported herein was to review the current Army Doctrine on Military Hydrology and recommend changes that would upgrade the hydrologic doctrine of the Army in terms of the most modern technology available and requirements for battlefield operations in the 1980's and 1990's time frame.

Scope

9. For the purpose of this study, hydrologic material was separated into four subject areas--meteorology, soil moisture, streamflow, and water supply. With reference to these categories, Army technical documents (i.e., Technical Manuals (TM), Technical Bulletins (TB), Field Manuals (FM), and Army Regulations (AR)) were reviewed to establish the adequacy of their contents with respect to current Army hydrologic data requirements. Army hydrologic data requirements were derived from the AR's and FM's reviewed and the U. S. Army Engineer Waterways Experiment Station (WES) Miscellaneous Paper EL-79-6, "Military Hydrology, Report 1, Status and Research Requirements."

10. In order to locate all hydrologic material needed for review, the list of documents in Department of the Army (DA) Pamphlet No. 310-3 (Index of Doctrinal, Training, and Organizational Publications, June 1977) was examined and those related to hydrology were selected. A summary of

documents reviewed and their subject contents is included as Table 1. In addition to the technical data requirements for Army Operations, unit organizations were addressed to a limited extent in the review process.

11. Part II of this report provides a description of the conduct of the study and a summary of the results broken down by the four major military hydrology thrust areas--meteorology, soil moisture, streamflow, and water supply. Part III presents the major conclusions and recommendations from the study. A prospectus for each document reviewed is presented in Appendix A. The information in Appendix A should be read with a copy of the appropriate reviewed document in hand since specific comments and recommendations are not always self-explanatory.

PART II: CONDUCT AND RESULTS OF DOCTRINE REVIEW

Conduct of Review

12. Each document listed in Table 1 was examined to determine which portions, if any, did not provide up-to-date guidance on hydrologic organizations, material, or procedures with respect to the Army hydrologic data needs for the 1980's and 1990's. A prospectus for the information presented in each document and an evaluation of the contents was prepared, including specific recommendations for upgrading any portions found to be out of date. The prospectus for each document was divided into a brief statement of purpose, a summary of the contents, comments on the shortfalls of the content, and recommendations for improvements.

13. The prospectus prepared for each document reviewed is presented in Appendix A. The information provided in the prospectuses was summarized with respect to the four major subject areas being addressed in the military hydrology research program--meteorology, soil moisture, streamflow, and water supply. These summaries are presented in the following paragraphs to provide a synopsis of the status of doctrine in each of these subject areas.

Summary of Review

Meteorology

14. Weather, especially precipitation, is a critically important aspect of military hydrology. Accurate precipitation measurements and forecasts are essential for estimating streamflow parameters, soil moisture and trafficability, and availability of water and water sources.

15. The meteorological information provided in the current manuals is limited to descriptions of weather and conditions which produce it. No mention is made of its value to the hydrologist in forecasting.

16. In addition to understanding the weather, the hydrologist should have some knowledge of how it is observed and of the intelligence products available from meteorological stations or weather offices.

17. The overriding importance of rainfall makes its observation and forecasting critical. The hydrologist should not only be aware of the methods of its measurement, but also of the limitations and capabilities of the equipment used. Radar and satellite techniques are of particular importance because they constitute the only practical means for areally observing rainfall in enemy territory; they should be discussed at length. Of the doctrine reviewed, only TB 5-550-3 (Flood Prediction Techniques) disusses weather radar, but the presentation is out of date and needs expansion. Present manuals should discuss types of radar data that can be obtained and how to use these data for soil moisture and streamflow forecasts.

18. The value of radar for observing weather systems is demonstrated by National Weather Service applications. By having a good working knowledge of weather radar and its applications, it is possible for a hydrologist to make a more accurate assessment of the rapidly changing conditions during severe weather. Although no tactical weather radars have yet been fielded, the terrain team should be aware of how to communicate with tactical weather radar personnel and how to use the data. These points should be presented in the current doctrine.

19. One of the streamflow manuals should contain a chapter presenting techniques for measuring and forecasting precipitation so that the hydrologist will know how the data are obtained and the limitations associated with its use.

Soil moisture

20. Soil moisture is of interest to the hydrologist for several reasons. Of primary interest is its direct impact on runoff and therefore, streamflow. Streamflow conditions affect the performance of materiel items such as bridges and swimming equipment and also influence the location of support facilities. Trafficability is directly influenced by soil moisture.

21. During the Korean conflict in the Eighth Army section, river rises of 3 to 6 m within a single hour were not uncommon. To a field Army operating in an area that is nearly devoid of all-weather roads and bridges, such floods presented tremendous problems. During the summers of 1951 and 1952, the Eighth Army suffered serious flood losses in lives, equipment, and installations, particularly bridges. Between the flood seasons of 1952 and 1953, a flood prediction service was established to forecast flood levels and, thus, minimize associated damages; the effort proved quite successful.

22. One important function of this service was to determine soil moisture as an input to the hydrologic models. Proper antecedent soil moisture conditions are required model inputs for flood forecasting and trafficability reports.

23. The determination of soil moisture is a difficult task. Weather, land cover and use, topography, surface drainage, and physical properties of the soil all influence soil moisture. Some of these can be measured by remote means accurately enough for flood forecasting. Properties of the soil are difficult to measure and are critical inputs to hydrologic modeling. Measuring soil moisture directly by current remote sensing techniques is difficult because surface conditions must be used to infer subsurface conditions.

24. The present doctrine addresses soil moisture mostly as it relates to trafficability. The manuals of major importance concerning trafficability and cross-country movement are FM 30-10 (Military Geographic Intelligence (Terrain)) and TM 5-330/AFM 86-3 (Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations).

25. Very little information is available to the soldier for determining soil moisture. A manual or bulletin should address measuring or determining soil moisture and using it as an input to hydrologic models. In the future, total water balance models may play an important role in predicting cross-country movement capability and making streamflow forecasts. Soil moisture is an important element in the total water balance,

and techniques for estimating it should be made available.

Streamflow

26. In the streamflow category there are several areas of concern. Flood forecasting is usually the first to come to mind. Along with this are predictions of stream width, depth, current velocity, discharge, and area flooded. These parameters are important for all streams, large and small. Other water bodies (e.g., lakes, ponds, and reservoirs) are also of military relevance and must be considered. Finally, the breaching of dams and the routing of the resultant flood-wave is a specialized area of concern that is included in the streamflow category.

27. The terrain team is responsible for providing streamflow information. It is, therefore, important to point out that at present even if the streamflow manuals were up to date, individuals assigned to the terrain team do not have the technical background to use these manuals to make forecasts and monitor streamflow with any degree of confidence.

28. Of the documents reviewed in this area, many were nontechnical and concerned more with organization and responsibilities than hydrologic technology. While most of these general documents are shown in Appendix A as having only minor limitations and not being outdated, this evaluation is only in reference to streamflow monitoring and forecasting technology. The manuals may be outdated in other aspects.

29. The manual incorporating the highest level of hydrologic technology is TB 5-550-3 (Flood Prediction Techniques). This manual is directed primarily at flood forecasting for major rivers with adequate historical information. Flood forecasting for major rivers is generally not a difficult problem, but flood forecasting on small streams with short response time and limited historical data is a major problem for the military hydrologist.

30. The contents of several of the manuals reviewed are obsolete. It is possible that in some cases the obsolete manuals should not be updated but their use discontinued and the material repackaged to better provide for the needs of the modern Army.

31. Several areas can be improved upon. Many graphic techniques

can be directly adapted to programmable hand calculators. The ease of computation which this adds may then permit the introduction of other methods such as time-scale analysis. New methods, such as the Soil Conservation Service (SCS) curve number technique for predicting runoff and the SCS dimensionless unit hydrograph, should be added. Finally, with the computer technology available today, new event simulation and eventually continuous streamflow simulation computer models can be developed specifically for military use. With remote measuring devices and remote sensing techniques for precipitation along with a digital terrain data base, flood forecasts can be made in a matter of minutes.

32. It is recommended that two manuals be published in the streamflow area. These manuals should be written for the hydrologist on the terrain team with the understanding that the user has knowledge of the material in FM 30-10 (Military Geographic Intelligence (Terrain)) and FM 21-30 (Terrain Analysis). Also the user would be expected to have an adequate background in math, computers, and remote sensing. One manual would be directed toward drainage analysis and streamflow monitoring and forecasting. The other would be directed toward remote sensing, precipitation monitoring, hydrologic computer modeling, and dam breach analysis. Both manuals should cover problems associated with measuring and forecasting streamflows in cold regions.

Water supply

33. The soldier's water supply affects his health and general welfare and, subsequently, his combat efficiency and morale. Without water, the soldier is out of action in a few days. In extremely hot areas, or in cases of extreme physical exertion, his limit is 16 hours. Not only is drinking water necessary, but also water for bathing, washing clothes, cooking, vehicle cooling, engineering construction, and machinery is required.

34. Since the organization of the Army's Rapid Deployment Force (RDF), much emphasis has been put on establishing water requirements and methods of supplying water to troops, especially in arid climates. Approximately 60 percent of the water for the RDF must be potable, and

the rest must be salt-free for showers, vehicles, laundry, etc. The large water volume requirements introduce tremendous logistics problems and other complications that should be, but are not always, addressed in the doctrine.

35. To meet freshwater needs, water is generally obtained from either surface or underground sources. Uncontaminated surface water sources are generally quick and easy to develop. It has been estimated that about 97 percent of the earth's freshwater (not counting that which is in the ice of glaciers and of the polar ice caps) is located underground, and in many regions, especially arid ones, the majority of freshwater must come from underground sources. It is therefore imperative that the Army know how to locate and develop these underground supplies.

36. To determine areas of weakness in finding and developing water sources, the Army's Field and Technical Manuals on these subjects were reviewed. Of the manuals reviewed, some covered groundwater only in general terms or did not cover the subject at all. It is believed that the principal reason for this is that these manuals were not designed for providing detailed techniques for locating sources of groundwater in arid or other climatic regions. With the exception of cold regions, the development of water sources was covered adequately, including well-drilling operations and filtering operations to make water both potable and palatable according to STANAG 2136. Cold regions are important and should be covered more thoroughly than they are at present.

37. FM 5-166 (Well Drilling Operations) had the most coverage on groundwater. The information presented, however, was too general. The manual that should cover groundwater in detail is TM 5-700, "Field Water Supply," but this manual is primarily devoted to surface water development; groundwater location is discussed only in general terms.

38. Therefore, expanding an existing manual (TM 5-700) or preparing a new one in the area of groundwater location is necessary if the Army is to carry out its responsibility for locating well sites for groundwater development. It is recommended that a new manual be written, directed toward locating groundwater and that TM 5-700 be kept primarily the same

(i.e., oriented toward development). This new manual should cover arid and cold regions equally since both areas are likely Theaters of Operation.

PART III: CONCLUSIONS AND RECOMMENDATIONS

39. With reference to meteorology, an important point to be made is that the Army's mission in this area is not clearly set forth. AR 115-10/AFR 105-3 should define this mission, but even the latest revision of this AR (15 September 1980) is ambiguous. There is also a need for a chapter in one of the streamflow manuals covering the topics of precipitation forecasting, communications (getting the information from the field to the hydrologists), and fundamentals of meteorology. Current manuals on the subject should serve only as reference material.

40. Documents that are available in the soil moisture category are limited to trafficability applications. A new manual should be written or a section should be included in streamflow forecasting manuals discussing soil moisture as it relates to streamflow forecasts. Physical methods of measuring soil moisture should be discussed as well as estimation methods.

41. At present the major streamflow manual is TB 5-550-3. Although much of this information is still valid, the manual lacks some of the newer hydrologic procedures such as the SCS curve number procedure for estimating runoff, and the SCS dimensionless unit hydrograph. Response time requirements have made most of the procedure outlined in this manual too slow to be of much use except as backup procedures. New computer (microprocesser and hand-held calculator) techniques are a must to achieve the rapid forecasting response time demanded in the modern Army. Two manuals should be written in the streamflow category--one directed toward drainage analysis and streamflow monitoring and forecasting, and the other directed toward remote sensing, precipitation monitoring, hydrologic computer modeling and dam breach analysis. TB 5-550-3 can be kept as a reference if it is updated.

42. The water supply manuals require changes in two areas. TM 5-700 should be updated to include new water purification equipment and new doctrinal changes. Also, there is no manual directed toward locating underground water sources. A new manual should be written to

include sources of reference materials on developed underground water supplies and techniques for locating well sites encompassing remote sensing techniques, geologic and surface indicators, and geophysical techniques.

Table 1

Summary of Army Doctrine Reviewed

Manual		Subject Categories Addressed				
Manual No.	Title	Organization	Meteorology	Soil Moisture	Streamflow	Water Supply
AR 115-10/ AFR 105-3	Meteorological Support for the U. S. Army	X				
AR 115-12	U. S. Army Requirements for Weather Service Support	X				
AR 115-21/ AFR 105-10	Military Hydrology	X		X	X	X
FM 5-30	Engineer Intelligence	X				
FM 5-146	Engineer Topographic Units	X		X		X
FM 5-166/ AFR 85-23	Well Drilling Operations					
FM 6-15	Field Artillery Meteorology		X			
FM 21-32	Topographic Support	X				
FM 21-33	Terrain Analysis			X	X	X
FM 30-10	Military Geographic Intelligence		X	X	X	X
FM 31-3/ AFM 105-4	Weather Support for Field Army Tactical Operations		X			
TB 5-550-1	Flood Prediction Services	X			X	

(Continued)

Table 1 (Concluded)

Manual		Subject Categories Addressed				
Manual No.	Title	Organization	Meteorology	Soil Moisture	Streamflow	Water Supply
TB 5-550-2	Compilation of Intelligence on Military Hydrology				X	
TB 5-550-3	Flood Prediction Techniques				X	
TM 5-235	Special Surveys				X	X
TM 5-330/ AFM 86-3	Planning and Design of Roads, Airbases, and Heliports in the Theater of Operations			X		
TM 5-545	Geology					X
TM 5-700	Field Water Supply					X
TM 5-813-2	Water Supply Water Sources					X

APPENDIX A: PROSPECTUS FOR DOCUMENTS REVIEWED

Contents

AR 115-10/AFR 105-3

Meteorological Support for the U. S. Army

September 1980

Purpose

This regulation provides policy and direction to Army and Air Force elements engaged in meteorological support of the Army.

Summary

This revision updates Army weather and other meteorological support requirements. It clarifies Army and Air Force responsibilities for providing meteorological support to the Army, the functions and relationships of the Staff Weather Officer and Army Intelligence Officer, responsibilities for providing communications for acquisition and dissemination of weather information, and related administrative and logistical support.

Comments

This new AR appears suitable with one exception. Paragraph 1-8 states that the "Army has primary responsibility to fulfill the following weather support requirements. ...(3) Soil trafficability, river stage, and flood forecasts, based on Army hydrological measurements and Air Force weather information." This statement confuses rather than clarifies Army responsibility for meteorological support.

Recommendations

If it is the Air Force's responsibility to provide meteorological support for soil trafficability, river stage, and flood forecasts, this reference, i.e., responsibility (3), should be deleted from paragraph 1-8 which talks about Army responsibilities for providing weather support.

AR 115-12

U. S. Army Requirements for Weather Service Support

January 1978

Purpose

This regulation describes policy and procedures to be followed by Army commanders in requesting weather service support. This support is further described in AR 115-10/AFR 105-3 and FM 31-3.

Summary

This regulation outlines the procedures for preparing U. S. Army requirements for weather service support and the submission of these requirements through channels to the Department of the Army and, thence, to the Department of the Air Force in accordance with AR 115-10/ AFR 105-3. Army meteorological support requirements, such as meteorological observations for direct support of Army weapons systems and meteorological support of Army research, development, test and evaluation activities, are not addressed by this regulation.

Comments

Remote weather service (located outside the Army unit) is provided by the Staff Weather Officer (SWO) and/or Air Force or Navy weather service unit, Weather Bureau Station, or Flight Service Station of the Federal Aviation Administration. When remote service is not available or unsatisfactory, a statement of requirements (SOR) for direct weather service support is submitted to a major U. S. Army command headquarters. Corps, divisions, and separate brigades in a combat environment are provided full-time weather service support by attached Air Force weather units. Requirements which cannot be fulfilled without research and development are submitted to the Deputy Chief of Staff for Research, Development, and Acquisition in accordance with procedures established in AR 70-1.

Specifications on what information is to be included in the SOR are not included.

Recommendations

It is recommended that a section discussing information to be contained in an SOR be included.

AR 115-21/AFR 105-10
Military Hydrology
May 1977

Purpose

This regulation defines the scope of military hydrology and assigns responsibility for providing hydrologic information to the U. S. Armed Forces.

Summary

This regulation assigns the Chief of Staff, U. S. Army, the responsibility for military hydrology for the U. S. Armed Forces by authority of the Joint Chiefs of Staff. The Chief of Staff, U. S. Army, has assigned to the Chief of Engineers (COE) responsibility for performing the functions and activities which are divided into two parts: those dealing with research and development and those dealing with support of operational elements.

All research and development activities relating to military hydrology are the responsibility of the COE. In the Continental United States (CONUS) and other territories of the United States, the COE is responsible for providing military hydrology services and functions required for direct support of operational elements. In theaters of operation and overseas commands, terrain analysis elements of Army forces are responsible for providing military hydrologic information to all deployed units. Where no terrain analysis element is present or available, staff engineers are assigned this responsibility.

The Chief of Staff, U. S. Air Force, has been assigned responsibility by the Joint Chiefs of Staff to provide meteorological information to the Chief of Staff, U. S. Army. The Chief of Staff, U. S. Air Force, has assigned responsibility for providing meteorological data and weather forecasts to the Commander, Air Weather Service. Commanders of Air Weather Service elements are assigned responsibility for such services in theaters of operations.

Comments

None.

Recommendations

None.

FM 5-30

Engineer Intelligence

September 1967

Purpose

This manual is a training text and general reference for all personnel concerned with engineer intelligence. It serves as a guide for commanders and their staffs in understanding the purpose and scope of engineer intelligence and how the engineers may be utilized to meet their intelligence requirements.

Summary

The information in this manual deals with the concept and role of engineer intelligence both in the zone of the interior and in the theater of operations.

Comments

The list of captions on page 4, paragraph 5c, should be checked to make sure that it includes all needed categories of intelligence.

On page 36, Figure 7 shows a flowchart of theater engineer intelligence. This chart is out of date relevant to the terrain team organization and placement and is out of date in other respects also.

In Chapter 9, pages 41-43, various topographic and intelligence teams are listed and described in terms of capability, basis of allocation, strength, and mobility. These teams have been reorganized under TOE 5-540. The new TOE and discussion of mission and control is presented in FM 5-146, Engineer Topographic Units, Chapter 3. In particular, Team IL, Military Hydrology, is no longer in existence. The military hydrology capability now is the responsibility of the terrain teams as set forth in TOE 5-336, 5-540 IJ, and 5-540 IK.

Recommendations

It is recommended that this manual be updated with the correct organization and structure of terrain units included.

FM 5-146

Engineer Topographic Units

September 1979

Purpose

This manual presents doctrine and guidance on the mission, organization, capabilities, and employment of engineer topographic units. It is designed to guide staff officers and unit commanders responsible for directing and conducting topographic operations and training.

Summary*

In Figure 1-1, page 1-2, terrain teams are shown as being placed at Echelon Above Corps (EAC or Theater Army Level), Corps, and Division levels. The Theater Army Team is part of Headquarters and Headquarters Company, Engineer Topographic Battalion (TOE 5-336); the Corps Terrain Team is separately organized under TOE 5-540 IJ and assigned to the Topographic Battalion on a basis of one per supported Corps. The Corps Team has one terrain team (TOE 5-540 IK) assigned per division. The Corps Team leader oversees and coordinates Division Team activities.

On page 1-4 under Command, Control, and Liaison supervisory channels under which the terrain teams operate are given.

Figure 2-2 on page 2-3 shows the terrain team position within the HHC of the Engineer Topographic Battalion.

The Theater Army Terrain Team is used for general support of Theater Army headquarters and its supporting units. This team has a headquarters and three sections including the Collection Section, Interpretation and Analysis Section, and the Information Section which operate from the Topographic Support System (TSS) Military Geographic Information (MGI) modules. These sections are discussed on page 2-11. Mobility

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* The material in this manual is summarized and discussed only as it relates to military hydrology.

and communications limitations nd requirements are discussed on page 2-12.

Chapter 3 covers the topographic teams organized under TOE 5-540 to provide specialized personnel and equipment for specific missions or for unit augmentation. These include the Corps Terrain Team (TOE 5-540 IJ) and the Division Terrain Team (TOE 5-540 IK). Also discussed are the data bases in which military geographic information is stored, employment, task and structure, and the Collection, Interpretation and Analysis, and Information Sections of the Corps terrain teams and team headquarters. Generally the same topics are discussed for the division terrain team.

References and a glossary are presented in Appendix A and B, respectively.

Comments

This manual sets forth terrain team positions within the Army structure along with its mission and supervision.

Recommendations

Manuals pertaining to military hydrology should contain reference to this publication.

FM 5-166/AFR 85-23
Well Drilling Operations
June 1975

Purpose

The purpose of this manual is to serve as an introductory text on groundwater usage and water well-drilling operations. It is primarily intended for military personnel responsible for developing groundwater as a water source in the field, but it may also be used for guidance in drilling water wells for permanent military installations. Auxiliary uses of water well-drilling equipment, such as providing geologic or soil data, are also covered. This manual may be used as a text for training personnel in groundwater usage, water well-drilling operations, and related uses of the associated equipment.

Summary

The most important aspects of groundwater, including its origin, occurrence, quality, and exploration are covered in this manual. Well construction methods most frequently used by military organizations (the rotary and downhole techniques) are covered, and miscellaneous methods are presented for use when standard military well-drilling equipment is not available. Several types of equipment and methods normally used only in civil practice but which may in certain situations be adopted for military use are also described. The techniques of completing, developing, and testing wells after the hole has been drilled are presented. Arctic well construction and its unique problems are discussed, and the auxiliary uses of well-drilling equipment for rock and soil sampling are covered. The different types of pumps that are used to lift water from inside a well to the surface are also described.

Comments

Chapter 2 (Groundwater) is the only chapter that deals with

hydrology. The other chapters discuss hardware systems and how to use them in well-drilling operations. While general, this chapter presents accurate background material. In Section III, Exploration of Groundwater, fracture zones should be included as geologic features likely to hold groundwater. Specific guidance for locating groundwater sources in arid regions is inadequate.

Recommendations

A new manual should be written and devoted entirely to locating water sources.

FM 6-15

Field Artillery Meteorology

August 1978

Purpose

This manual addresses the meteorological requirements of the field artillery.

Summary

This manual covers all the tasks required to select a meteorological station site and to prepare and deliver artillery meteorological messages.

Comments

This FM relates only indirectly to military hydrology problems.

Chapter 2

Page 9, paragraph 2-11: Part (2) under Message Body is not complete. All of Section I is oriented toward Artillery Meteorological Section requirements. A chapter covering the same material, but in more detail, could well be included in the Terrain Analysis Field Manual.

Chapter 3

Page 4, paragraph 3-4: There is no rain gage included in the list of Meteorological Section equipment. An Artillery Meteorological Section is assigned to each Artillery Brigade operating independently. Each Meteorological Section consists of 11 people trained in some of the fundamentals of weather observation. If Meteorological Sections were required to obtain rainfall measurements in addition to other duties, these rainfall measurements would be of value to the hydrologists; however, the problem of communication of these data is a factor to consider.

Recommendations

The Artillery Meteorological Section has been tasked to take surface weather observations in addition to upper air soundings. This manual should be updated to reflect current mission requirements.

FM 21-32

Topographic Support

September 1979

Purpose

This manual sets forth the fundamental doctrine regarding topographic support to the Army. It provides the topographic specialist, as well as the supported unit or individual user, with the objectives of topographic support, what it consists of, and how it is carried out.

Summary*

In Figure 2-2, page 2-4, the placement of terrain teams within the national topographic community is shown.

On pages 4-8, Figures 4-2, the position of the terrain teams within the Engineer Topographic Battalion (ETB) is shown.

According to information presented in page 4-10, the headquarters and headquarters company (HHC) of the ETB contains one terrain team available for Theater general support. One Corps terrain team is assigned to the battalion for each supported Corps in direct support of the Corps. Also, a Division terrain team will be in direct support of each division and assigned to the parent Corps terrain team.

On pages 4-11, the supervisory channels under which the terrain team operates are given. The team is dependent upon the command to which it is allocated for administrative, logistical, and housekeeping support.

Table 6-1, on pages 6-7 shows the allocation of collection, analysis, information, synthesis, and direct support groups to the terrain teams of Theater Army, Corps, and Division level. Also, on pages 6-7 and 6-8 the Army Terrain Information System (ARTINS) is discussed. ARTINS is conceptually an automated tactical data system designed to

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* The material in this manual is summarized and discussed only with regard to the terrain team which is the team responsible for analyzing and providing military hydrologic data.

provide the topographic terrain teams with a capability for automated storage and rapid analysis of large amounts of terrain data.

Comments

None.

Recommendations

ARTINS is not in the Army inventory and portions concerning it should be deleted from the document.

FM 21-33

Terrain Analysis

May 1978

Purpose

This manual is intended to assist in identifying the duties of the Terrain Analyst and to serve as a reference.

Summary

The manual was written for an enlisted Terrain Analyst and is used as part of the Terrain Analyst course for enlisted grades E5 to E7.

Terrain analysis is the process of analyzing a geographical area to determine the effect of the natural and man-made features on military operations. This manual describes the procedures to be followed by the Terrain Analyst including data collection, management, and use of data files, analysis of terrain factors, preparation of special purpose maps, and preparation and distribution of terrain studies. Chapter 2 (Collect Data) includes discussions of kinds of data and where they can be obtained.

Chapter 5 (Analysis Terrain Factors) includes the bulk of the material in this manual. It is divided into seven sections: (1) Prepare Climatic Summaries, (2) Analyze Drainage Features, (3) Analyze Surface Configuration, (4) Analyze Geology and Soils, (5) Analyze Vegetation, (6) Analyze Beaches, and (7) Analyze Man-Made Features. The primary intelligence products to be developed under the guidelines of sections (2) through (7) are map overlays and supporting data files for each of the six topics.

Comments

This manual is easy to read and has numerous sketches and examples. It deals primarily with procedures for accomplishing the various jobs of the Terrain Analyst.

The section on drainage analysis provides only general procedures for delineating the drainage system, wet areas, and areas subject to flooding; estimating the channel cross section, water depth, and stream velocity; and describing significant structures. A primary limitation of this section is that it does not include procedures for estimating the accuracy of the results. The guidelines presented in this section along with references listed in the Appendix (FM 30-10 and TM 5-545) are not adequate for a Terrain Analyst to make a reliable drainage analysis of an area.

Chapter 1

Page 6, Section 2, Sources of Climatic Data: A good discussion is given on possible sources of climatic information. The data file at ETAC is incomplete and this fact should be clearly noted.

Chapter 5

Page 2, Section 1, Climatic Data and Analysis: The climatic summary is of little value to the Terrain Analyst. The reference to the figure on page 2-9 of FM 30-10 is not necessary.

Page 3, Section 1, Weather and Terrain: If the Terrain Analyst is really tasked to provide the information outlined on page 3, he must be given more training in meteorology. The Terrain Analyst must have direct communication with the Staff Weather Officer (SWO) on a daily (or more frequent) basis in order to carry out his mission. Communication difficulties in a tactical situation could force the Terrain Analyst to operate without the benefit of the SWO, a situation for which the Terrain Analyst is not adequately trained.

Page 8, Section 2, General Information About . . . . : The rivers and streams checklist should include data on specific cross sections of the channel and valley.

Page 21, Section 3, How to Measure Slopes: The formula: % slope x 100 = VD/HD should be changed to: % slope = 100 VD/HD. Also, the term (100 ft VD) in the next to last equation should be centered under (for five 20-ft contour intervals) to make sure one knows this term goes with the numerator.

Page 43, Section 5, How to Prepare an Overlay: The placement of the unit identification numbers is confusing when reading the text and comparing it to this overlay.

Chapter 6

Page 13, Section 7, Prepare Other Special Purpose Maps: The discussion on water supply under part 4 is very brief but sufficient for this reference.

Recommendations

It is recommended that two hydrology manuals devoted entirely to hydrology be developed and that a summary of the drainage analysis section be presented in FM 21-33. The proposed manuals should include a full range of procedures starting with simple methods and extending to computer models. This and other related texts should be referenced in the two new manuals.

FM 30-10

Military Geographic Intelligence (Terrain)

March 1972

Purpose

FM 30-10 is intended to serve as a guide to the preparation of geographic intelligence products and, as such, to describe methods for the collection and interpretation of geographic or terrain data from a variety of sources.

Summary

FM 30-10 treats the geographic aspects of the battlefield as intelligence products and concerns itself with the collection and organization of that intelligence. It is directed to the terrain unit which has the responsibility for gathering terrain intelligence and deals at length with the effect of terrain features on military operations. It contains sections devoted to hydrology, water supply, and waterways and an entire chapter on weather and climate. However, these items are considered only as observables with no attention given to either their time-variable nature or their predictions. The manual is restricted throughout to the tabulating and reporting of observed conditions.

Comments

The hydrologic information presented in this FM, although general, is useful for a reference. The forecasting of soil and stream conditions is an intelligence responsibility of the Engineer Terrain units, and the technology that exists today is well beyond that reflected by this FM.

Specific comments are given in the following:

Chapter 2

Paragraph 2: The discussion of climatic regimes is inadequate. Materials presented may be useful as background information, but without further detail are virtually useless to the hydrologist. Figures 2-1, 2-2, and 2-3 would be more appropriately included here. Significant hydrologic features of tropical climates should be mentioned.

Paragraph 7, Figures 4 and 5: The figures are not self-explanatory. Their value is lost by the lack of discussion. The scale of the figures is not discernible, and features are not described adequately. The hydrologist would like to know more at this point about drainage, depth of frost line, soil strength, etc.

Paragraph 8: The Environmental Technical Applications Center (ETAC) data base has many gaps which limit its utility for detailed hydrologic studies. This should be pointed out as well as the fact that supplementary data are necessary.

Paragraph 9: The example, Figure 2-6, of a climatic summary would be of little value to the terrain team. The hydrologist needs real-time and forecast precipitation information.

Paragraph 11: How air temperature data are used is not adequately discussed. The relation of temperature and evaporation is not mentioned.

Paragraph 12: The standard reduction of pressure to sea level by stations above sea level is not mentioned. A person could confuse sea level pressure with station pressure.

Paragraph 13: Table 2-1 is now obsolete. One could be used from the Federal Meteorological Handbook (FMH). d. Chinook: The terrain team needs to know that Chinook winds can cause rapid snow melt and drying of the soil. In general, the special winds mentioned are never given any significance that relates to the terrain team.

Paragraph 14: The definitions, vapor amount and dew point, are not exactly correct, and no mention of their relevance to the terrain team is given.

Paragraph 15: Figure 2-8 cloud cover symbols are no longer used. FMH will be the new source. Cloud heights are still being reported in feet in the United States. d. Appearance: The FAA handbook "Pilot's

Meteorology" has a better commentary and pictures on clouds than this section. Figure 29 "major cloud types" leaves one more confused than enlightened.

Paragraph 16: Figure 2-10 is almost useless in this FM. The caption under this figure does not state if these are monthly or yearly amounts. Because of the importance of precipitation, more space should be devoted to it. b. Character: Consult the FMH for changes in these criteria. A useful addition here would be a section from the FMH on visual estimation of rainfall intensity that translates into millimeters or inches per hour. A person could use this if there were no rain gage(s) available. Accepted definitions should be taken from FMH. d. Amount: How snow depth is measured is not given, nor is a definition of "representative sample."

Paragraph 18: The section on thunderstorms and tornadoes needs an extensive update. Thunderstorms often deposit considerable amounts of rain, and an appropriate figure should be included. There are several good ones that relate the gust front, cloud height, and direction of movement to the rainfall event. c. Tropical cyclones: Figure 2-11 is not needed; material should be updated.

Paragraph 19: Some mention should be made of computer technology. Figure 2-12 is no longer appropriate; the current Air Weather Service (AWS) format should be used. Artillery meteorological teams provide information on fallout winds which should be mentioned.

Paragraph 20: e. Information sources: It is questionable whether these Army units really pass information to other units. Forward combat units probably would not be in position to collect weather data.

Paragraph 21: The discussion needs to be expanded, especially with reference to site selection.

Paragraph 22: No mention is made of wind effect on evaporation and drying of soils.

Paragraph 24: In general, this section is satisfactory but needs some expansion.

Paragraph 25: Figure 2-13, seasonal distribution of rainfall, contributes nothing. Expansion of this section is also needed.

Paragraph 26: This section could be combined with paragraphs 2-28, 2-29, 2-30, 2-31 and 2-32. This paragraph really adds little to the overall objective of this section.

Paragraph 27: The title, "Importance of Restricted Commanders," is poor. The commanders are not restricted, conditions are.

Paragraph 29: This paragraph is good as far as it goes but could use some elaboration.

Paragraph 30: Stream crossing and lowland flooding are not mentioned, nor is soil variability.

Paragraph 32: For aircraft operations, temperature and the pressure-altitude factor determine the length of runway needed for aircraft takeoff.

Chapter 3

Paragraph 18, Figure 3-9: This figure needs an explanation. Other references to meteorological factors in this section appear to be satisfactory.

Chapter 4

Paragraph 18: Snow is covered here in a trafficability sense rather than meteorological. This also applies to paragraphs 4-19 and 4-20. Remote sensing of soil moisture is not covered in this section.

Chapter 5

Paragraph 52: Sentence duplicated in first paragraph.

Paragraph 73: Meteorology is discussed again in Chapter 5. This paragraph indicates that weather data and weather forecasts can be found at some airfields. Figure 5-63, a photo of a weather radar, is superfluous.

Recommendations

The information in this manual on hydrologic intelligence should be expanded and included in FM 5-30, Engineer Intelligence. The formats in FM 30-10 for intelligence products are good as is the guideline for their preparation. These should be easily adaptable to hydrologic products. Also a chapter in one of the streamflow manuals should be written to include precipitation forecasting, communication, and basic meteorology. This FM after revision could be used as a reference.

FM 31-3/AFM 105-4

Weather Support for Field Army Tactical Operations

December 1969*

Purpose

This manual provides doctrinal guidance to U. S. Air Force (USAF), Air Weather Service (AWS), and field personnel, including commanders and staff officers, who are concerned with the weather support required for Army tactical operations. It consolidates and explains U. S. Army and AWS current doctrinal guidance on weather support services and functions provided for field army tactical operations, and provides guidance to field personnel and USAF staff weather officers and AWS personnel operating with field army headquarters and elements. The information is applicable to general war, limited war, cold war, and stability operations.

Summary

This manual covers weather effects, support requirements, and theoretical aspects of meteorology which concern field army operations. It describes sources of meteorological (met) and weather information, weather services provided, and communications support.

Comments

Chapter 1

Page 1, paragraph 2c, last sentence: Joint Chief of Staff (JCS) memorandum of Policy No. 46 states that the Air Force is responsible for meteorological support for river stage and flood forecasting. This will be stated in the revised Army Regulation AR 115-10/AFR 105-3. Therefore, this sentence should be deleted.

Chapter 2

Page 1, paragraph 3a, line 10: Although local weather conditions can be predicted on the basis of surrounding weather conditions, the

* This manual is currently being rewritten.

accuracy generally will not be adequate for hydrologic modeling.

Chapter 3

Page 2, paragraph 2f number (7): The engineer flood prediction service has been replaced by Theater Army, Corps, and Division level terrain teams. Therefore, this paragraph should be updated.

Page 3, 2nd column, number (11): The use of these radar units for tactical weather purposes should be presented in TB 5-550-3 (Flood Prediction Techniques) along with a data format and guidance on the use of the data.

Page 5, paragraphs 6-7: The text recommends that the Artillery Meteorological Section work closely with the AWS to provide mutual support. FM 6-15 (Field Artillery Meteorology) should contain a similar reference. Also, the field artillery meteorology team has been tasked to make surface weather observations in addition to upper air soundings. This new mission should be discussed.

Chapter 4

Page 2, Figure 1: This figure is outdated. The 5th Weather Squadron no longer operates in Vietnam.

General

The organizational charts behind the Appendix should be checked to make sure they are current.

Recommendations

In addition to the comments made above, recent changes in TOE's have been made which should be reflected in this manual.

TB 5-550-1

Flood Prediction Services

December 1956

Purpose

This bulletin presents a description of typical conditions under which flood prediction and flood warning services should be established for military purposes; it outlines the organizational arrangements and facilities needed to establish and operate such services under alternate circumstances; and it presents information and instructions of a general nature that would be useful in establishing a military flood prediction service.

Summary

This bulletin describes conditions under which a flood prediction service should be established and discusses the necessary organization arrangements and facilities to provide this service. The criteria for the establishment of a flood prediction service are presented in the form of three questions: (1) will a flood affect the military operation, (2) will the forecast be of sufficient military value to justify the effort, and (3) is it possible to gather the hydrologic data required to develop the forecast.

The flood prediction services are divided into three types based on the time of flood crest after the beginning of rise. The Local Flood Prediction Service would be established for small streams with a time to peak of less than 12 hours. A Regional Flood Prediction Service would be established for an area where the time to peak is between 12 and 30 hours. The Centralized Flood Prediction Service would be established in an area where the time to peak is more than 30 hours. The organizations required for the Local, Regional, and Centralized Flood Prediction Services are discussed in some detail. For example, the personnel required to provide flood prediction are as listed below:

	Officers	Enlisted
Local Flood Prediction Service		
Precipitation Section	1	14
Stream Gaging Section	1	8
Prediction Section	1	
Communications		2
Computers		4
Administrative and Supply Section	3	3
TOTAL	6	31
Regional Flood Prediction Service		
Precipitation Section	2	22
Stream Gaging Section	2	12
Prediction Section	2	
Communications		3
Computers		6
Administrative and Supply Section	4	4
TOTAL	10	47
Centralized Flood Prediction Service		
Precipitation Section	4	20
Stream Gaging Section	6	28
Prediction Section	6	
Communications		9
Computers		12
Administrative and Supply Section	8	11
TOTAL	24	80

Comments

The terrain team is currently responsible for collecting and analyzing hydrologic information. At the time this bulletin was written there was evidently no permanent organized group, such as the terrain team, with a flood prediction capability. Terrain teams at Division, Corps, and Theater Army level now replace the Local, Regional, and Centralized Flood Prediction Services. The centralized flood prediction service activities would be very similar to those provided by the National Weather Service in the U. S.

Little effort would be required to update the hydrologic technology presented in this bulletin. Most of the bulletin, however, is devoted to organizations which are no longer applicable.

Recommendations

The terrain teams fulfill the mission of the flood prediction services organizations as set forth in this bulletin; therefore, this bulletin should be discontinued.

TB 5-550-2

Compilation of Intelligence on Military Hydrology

January 1958

Purpose

This bulletin provides a valuable tool for training personnel and presents the compilation of intelligence on Military Hydrology as a simple checklist procedure.

Summary

This publication is a guide for the compilation of data on Military Hydrology. It provides a list of information items (with examples) required for specific hydrologic subjects. Information lists are provided for the following 12 subject areas: watersheds, river and canal channels, stream and river gages, precipitation gages, bridges, fords and ferries, dams and reservoirs, hydroelectric plants, flood protection structures, navigation locks, irrigation projects, and drainage projects.

Comments

This is an excellent publication in that it allows a technician with minimum training in hydrology to systematically compile required hydrologic data.

Recommendations

The information lists should be updated. A section should be included under the heading "Precipitation Gages" to assist with the collection and compilation of radar information. Although tactical weather radars are not currently in use, there is a strong possibility that they will be used in the future. The checklist for weather radar should include: location, organization that operates the unit, model number of unit, wavelength, and distance of ground clutter.

TB 5-550-3

Flood Prediction Techniques

February 1957

Purpose

The purpose of this bulletin is to present flood prediction techniques and procedures in a form suitable for military use.

Summary

This bulletin discusses basic hydrology and presents methods for forecasting floods. Of the hydrology manuals used by the Army, this bulletin presents the highest level of technology. Subjects discussed in detail include rainfall, precipitation-runoff relations, streamflow, hydrograph development, unit hydrograph construction, gage relations, flood routing, snow, and radar. Numerous examples are presented.

Comments

The emphasis in this bulletin is on flood forecasting for major rivers for which adequate historical information exists. Flood forecasting for major rivers is generally not a difficult problem, but flood forecasting on small streams with short response times and limited historical data is a major problem for the military hydrologist. The methods presented here may require modification for use on small and/or ungaged basins, basin types that are most frequently encountered.

Many of the graphic techniques can be directly adapted to programmable hand calculators. The ease of computation with calculators may then permit the introduction of other methods such as time-scale analysis. Hand calculators and microcomputers did not exist at the time of this publication.

In general, the section dealing with streamflow is a good presentation of the technology as it stood in the 1950's, but much progress has

been made since then. This is also true for weather monitoring and forecasting, and there should be a significant expansion of its treatment in the bulletin. Most prominent is the need to describe radar and satellite products and their applications, although these subjects would fit well in a terrain manual. In large basins one needs to know the actual distribution of rainfall for accurate forecasts, and the methods presented in this bulletin are not likely to provide sufficient detail in most cases. Some form of remote sensing is virtually mandated.

Specific comments follow:

Chapter 1

Page 3, paragraph 3b: Mention should be made of the fact that the terrain team now fulfills the mission of the old flood prediction services.

Page 4, paragraph 3c, line 16: There is a typographical error; "floor" should be "flood."

Page 4, paragraph 4, first two sentences: The flood prediction service is now the terrain team. Also TB 5-550-1, which is referenced, is no longer valid since it tells how to organize a flood prediction service.

Page 5, paragraph 8b: A calibrated radar has proven successful in estimating rainfall and perhaps does a better job area-wide than a single rain gage. Satellite observations have also been used but are not as accurate.

Chapter 2

Page 7, paragraph 14: The World Meteorological Organization has set standards for rain gages, but some countries still do not follow these standards. Table 1 should be checked to see if it needs to be revised.

Page 7, paragraph 14c: The U. S. Signal Corps is no longer found on organizational charts. The U. S. Weather Bureau is now the National Weather Service. This section should be compared with the Federal Meteorological Handbook.

Page 8, paragraphs 15, 16a, and 18: It should be determined if the Signal Corps currently has any weather responsibility.

Page 12, paragraph 23: DA Form 5129 should be checked to see if it is up to date.

Page 12, paragraph 24: Recent studies have shown that more rain gages may be required where the flooding problem is the result of thunderstorms.

Page 16, paragraph 25: Uniform distribution of gages in a tactical situation is unlikely.

Page 16, paragraph 28: Uses of the time distribution of rainfall should be pointed out.

Chapter 3

Page 26, paragraph 43a: In this paragraph it is stated that b would decrease as K^t, but in Figure 15 note that $b = t^k$. Figure 15 should be $b = K^t$.

Pages 27-31, Figures 10-14: The set of curves on the right in each of these figures with the abscissa labeled runoff (inches) should also have the ordinate labeled final index (FI). The premise of basing rainfall-runoff relation accuracies for the entire northern hemisphere on results for the Ohio River Basin is questionable.

Page 32, Table III: The initial API (column heading) in the left column should include units such as (API x 10^2 in.).

Page 35, paragraph 44b: The API method using Table III is 79 percent greater than API using the reciprocal technique. This is poor accuracy.

Page 36, paragraph 46b: It is not clear how to apply an adjustment.

Page 37, paragraph 50b, equation (2): It is not likely that one who can follow the material in this chapter will be unfamiliar with the conventional notation of math.

Page 37, paragraph 51a, line 10: The unit graph has not yet been defined so that the significance of this statement suffers.

Page 43, Figure 17: The abscissa needs a label. Also, the description of the various terrain types represented would be of more value than names.

Page 43, paragraph 54, equation (3): It is not likely that one who can follow the material in this chapter will be unfamiliar with the conventional notation of math.

In paragraphs 52-68, the details of the rationale are not as important as the application of the product. The entire section could be preprogrammed with a hand calculator with instructions for use. All the graphs in Chapter 3 can be readily programmed on a hand calculator. Other methods such as the Soil Conservation Service (SCS) curve number procedure should be included for computing runoff. The manual should offer programming guidance for hand calculators and minicomputers for specific programs.

Chapter 4

Page 58, paragraph 71b: DA 5-129 (Figure 27) and DA 5-131 (Figure 28) should be checked to see if they are still current.

Page 72, paragraph 85, line 4: There is a typographical error; "indentified" should be "identified."

Page 74, paragraph 89a: Step (1) should explain how to determine a relation between the discharge hydrograph of an index stream and a downstream point.

Page 75, paragraph 90b, line 12: The phrase "point 4" should be explained.

Page 76, paragraph 94a: The square root sign should be taken off S in equation (12).

Page 77, paragraph 95b: In equation (14) the large 1 and 2 in the numerator should be subscripts.

Page 77, paragraph 96: Figure 35 is not numbered.

Page 78, paragraph 97b: In equation (18) the square root sign should be replaced with a division sign.

Page 78, paragraph 97b: In defining the variables in equation (19) the H_1 should be a V_1 in the second definition. In the equation itself, the V2 should be V_2. Also both square root signs should be replaced by division signs.

Chapter 5

Page 81, paragraph 100b, line 2: There is a typographical error; "unit-fainfall" should be "unit-rainfall."

Page 81, paragraph 101: There is a typographical error; "instantaneuos" should be "instantaneous."

Page 84, paragraph 105: This method would be quicker with a hand calculator.

Page 86, paragraph 107: The duration of the distribution graph for comparison with the 6- and 24-hour unit graphs is not evident. The distribution graph should be discussed at greater length because of its applicability to data-sparse areas.

Page 86, paragraph 108: This method would be quicker using a programmable hand calculator. Storage of unit graphs in preprogrammed modules could be a powerful tool for the terrain team. Methods should be developed to accommodate the areal distribution of rain for larger basins.

Chapter 6

Page 94, paragraph 113: Tabulation of all relevant basin features would be better. The reference to Synder should be complete.

Page 95, paragraph 115: The definition of L_{ca} is very poor. L_{ca} should be defined as the river mileage from the outlet to a point on the river nearest the centroid of the basin.

Page 95, paragraph 116a (2): How does one know if $t_r \neq t_R$?

Chapter 6 should also include a discussion of the SCS dimensionless unit hydrograph and the Clark unit hydrograph.

Chapter 7

Page 116, Figure 56: This is a very poor quality reproduction and is difficult to read.

Chapter 8

Page 121, paragraph 138, line 6: The typographical error "food" should be corrected to "flood."

Page 147, paragraph 177, Table XXVII: The typographical error (Table title) "State Routing" should be corrected to "Stage Routing."

Chapter 10

Radar meteorology has advanced considerably since 1957. The FMH on radar meteorology contains a good discussion and could be condensed to replace this chapter.

Chapter 1

More examples should be given using more of the various techniques.

Recommendations

This bulletin was written in 1957; therefore, all of the methods presented here are manual techniques. Most of these techniques can be readily adapted to programmable hand calculators. Programming instructions and examples should be included. The SCS curve number procedure should be incorporated for estimating runoff. Also the SCS dimensionless unit hydrograph and the Clark unit hydrograph should be discussed. More techniques should be included on streamflow forecasting for small and/or ungaged watersheds. The radar chapter should be updated and methods used in radar data collection should be presented. New snowmelt routines have been developed and should be included. New routing techniques and hydrologic computer models should also be included in this manual. In essence, two new hydrology manuals should be written to take the place of this manual.

One manual would be directed toward drainage analysis and local streamflow monitoring and forecasting. The other would be directed toward remote sensing, modeling, and dam breach analysis.

TM 5-235
Special Surveys
September 1964

Purpose

This manual is a reference for engineer officers and technicians responsible for the supervision and conduct of special types of surveys, and describes the instruments and equipment to perform special surveys.

Summary

Various surveys discussed include underground surveys (Chapter 2), geologic and pedologic surveys (Chapter 3), land surveys (Chapter 4), hydrographic surveys (Chapter 5), shore-ship triangulation (Chapter 6), magnetic surveys (Chapter 7), and arctic surveys (Chapter 8).

The portions of the manual reviewed for this task were Chapter 3, Sections I (Geology) and II (Pedology), and Chapter 5, Sections III (Streamflow and Stream-Gaging Stations), IV (Stream-Gaging Equipment), and V (Measurement of Streamflow).

Comments

The section on geology and pedology deal with how to conduct surveys and prepare maps and appear adequate for this text.

In Chapter 5, Sections III-V, all the material presented is still relevant and can be used. Some of the equipment discussed may be out of date, but this does not prevent understanding or use of the text.

New developments in surveying equipment, e.g., electronic measuring devices, lasers, and digital recorders, should be discussed in this manual.

Some specific comments are listed below:

Chapter 5

Page 112, paragraph 229, line 4: The word "of" should be "or."

Page 114, Figure 88: This figure is upside down.

Page 123, Figure 101: This figure is upside down.

Page 134, paragraph 264: The last equation on this page should read

$$h = \frac{V2}{2g} = \frac{\frac{Q}{a}^2}{2g}$$

Recommendations

In the sections reviewed the methods used are up to date; however, the equipment discussed may need to be updated. A short-term effort would be required to update this manual to agree with the terrain team TOE. This update should discuss the hydrologic survey equipment set (K59089) and how to use it.

TM 5-330/AFM 86-3, Vol II
Planning and Design of Roads, Airbases, and Heliports
in the Theater of Operations
September 1968

Purpose

The purpose of this manual is to provide information and guidance to personnel responsible for the planning, design, and construction of theater of operations roads, air bases, and heliports. It is designed to be used as a reference handbook as well as a text for training and operation purposes.

Summary

Only the new working draft of Chapter 9 on Soils Trafficability was reviewed. This chapter covers the description and use of instruments and equipment and also tests performed to determine trafficability. The range in values of measurable soil parameters is presented. Also, empirical relations used to predict the number of passes over different soils and slopes that tracked and wheeled vehicles can make are presented.

Comments

There is nothing of relevance to obtaining soil moisture data for flood forecasting purposes. Soil moisture is handled in a qualitative manner.

Recommendations

None.

TM 5-545

Geology

July 1971

Purpose

The purpose of this manual is to relate the science of geology to military engineering. It is to be used for both reference and training. The manual is not intended to make geologists out of military engineers, but rather to present some of the geologic principles required for the correct solutions of many military engineering problems.

Summary

This manual includes a survey of basic geologic materials, features, and processes. It further describes the geologic factors that affect the properties and occurrence of natural construction materials, the construction of dams, tunnels, roads, airfields, and bridges, the location of water supplies, and terrain evaluation.

Comments

Although this entire manual provides information useful to the terrain analyst, chapters 4, 6, 7 and 9 have information of particular interest to the hydrologist.

Chapter 4, Weathering and Erosion, describes stream channel development, age, type, drainage patterns, and carrying capacity.

Chapter 6, Applications of Geology to Engineering Projects, discusses applications of geology to engineering projects including dams, tunnels, and bridges.

Chapter 7, Geology and Water Supply, includes a good but limited discussion of water supply.

Chapter 9, Field Geology, includes a discussion on Surface Geophysical Surveying. These various types of surveying techniques should

be expanded to include locating underground water sources.

Recommendations

In general, the material in this manual is adequate for the purpose intended. However, the material in Chapter 7 should be expanded and included in a new manual on locating water sources. The surveying techniques listed on page 9-3, paragraph 9-7, should also be discussed in the new manual as they pertain to locating groundwater.

TM 5-700
Field Water Supply
July 1967

Purpose

This manual is a reference and training guide for engineer personnel engaged in field water supply in field training exercises, combat zones, occupation areas, and other activities such as disaster relief. It also serves as a planning reference for engineer staffs at all levels, and as a reference for Army Medical Service personnel who inspect and approve water sources and treated water. This manual does not cover aspects of water treatment and inspection associated with municipal systems, nor does it contain information on water treatment by individuals or procedures for procuring water under survival situations.

Summary

The manual covers water quality and characteristics, water treatment processes, the establishment and development of water points, use of existing facilities, and contamination of water by chemical, biological, and radiological agents and industrial waste. Also covered are the basic steps involved in water purification, field tests, equipment operation, and establishing and developing water sources under arctic and desert conditions. The discussion of water points includes reconnaissance, field water sources, distribution and distribution facilities, and water supply records. Details on operation and maintenance of equipment, which can be found in applicable equipment manuals, are outside the scope of this manual.

Comments

This manual is well written and adequately covers the topics as set forth in the purpose and scope. However, the new reverse osmosis

equipment for purifying saline or brackish water is not included. Other pieces of equipment listed have never gotten into the Army inventory or perform very poorly, such as the 150-gpm distillation unit, and should be deleted.

Other comments follow:

Page 8, paragraph 17b, line 4: "hydrogen in" should be "hydrogen ion."

Page 40, paragraph 36a, (4), line 5: "a real geology my indicate" should be "areal geology may indicate."

Page 44, paragraph 43b, line 11: "signed" should be "signs."

Page 77, paragraph 75c, (1), line 5: "amounit" should be "amount."

Page 88, paragraph 79b, (6), line 6: "in" should be "is."

Page 91, paragraph 81a, line 5: "procelain" should be "porcelain."

Page 94, paragraph 82b, (5) line 13: "hyochlorite" should be "hypochlorite."

Page 117, paragraph 106: line 1 needs to be interchanged with line 2.

Page 131, paragraph 126f, line 7: "bottel" should be "bottle."

Chapter 3

This chapter on water reconnaissance could include a section on water resources overlays. The engineer reconnaissance report forms on pages 19-22 should be checked to see if they are current.

Chapter 4

The logs, summaries, and report forms listed on pages 52-57 should be checked to see if they are current.

Chapter 8

The results of some of the CBR agent tests are not clear. In other words, if you get a certain color change, is this a positive or negative response?

General

Emphasis throughout the entire manual is on surface water. Only two parts (paragraphs 32 and 36) deal with groundwater. This manual is basically a "how to handle it after you have it" reference.

Recommendations

This manual should remain basically the same except for the comments noted above. A separate manual should be written and devoted entirely to locating sources of water.

TM 5-813-2
Water Supply-Water Sources
July 1965

Purpose

This manual prescribes the procedures to be followed in obtaining and developing sources of potable water for Army and Air Force installations and for special projects. It describes general investigative procedures to be followed in determining the most feasible means of obtaining the required water supply. It establishes criteria to be followed in the development of underground or surface supplies, degree of treatment required, and types of pumping equipment to be used. A list of laboratory furniture, apparatus, and supplies required for water filtration plants is given in the Appendix.

Summary

Chapters 6, 7, and 8 provide an intelligence checklist for existing water supplies, well supplies, and surface supplies.

Chapter 9 gives the acceptable concentration of contaminants in a water supply.

Chapter 10 covers water supply wells. Subjects discussed include test drilling, well construction, types of housing and pumps to be used, metering of the supplied water, as well as the minimum number of wells required to provide sufficient water, their capacity, and the types of power units required for pumping.

Chapter 11 includes a discussion of well housing and pumping equipment for surface water pumping stations.

Chapter 12 includes a discussion of filtration plants.

Chapter 13 includes the type and capacity of pumps required to provide three million gallons per day.

The Appendix includes a list of laboratory furniture, apparatus, and supplies for water filtration plants.

Chemical, biological, and radiological contamination are not discussed, except for naturally occurring chemical contaminants.

Comments

None.

Recommendations

None.

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Stinson, David L.
Military hydrology : Report 3 : A review of army doctrine on military hydrology / by David L. Stinson (Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station, [1981].
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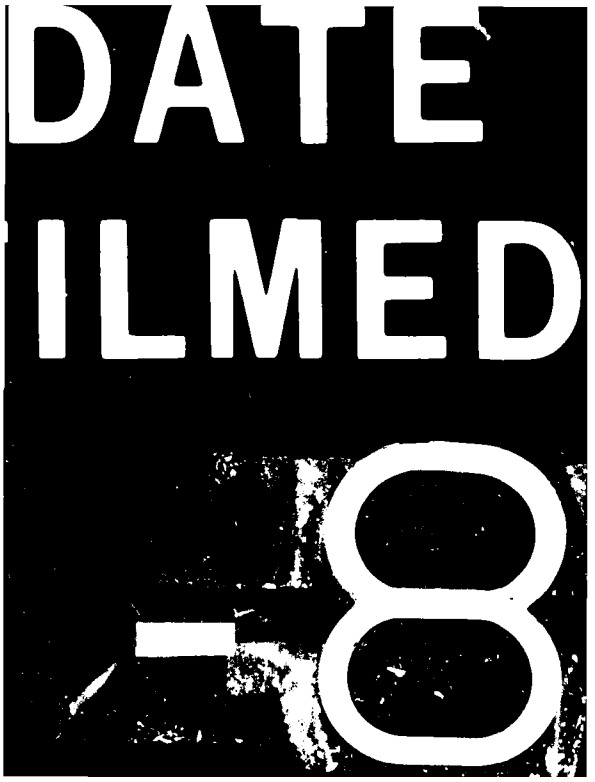
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